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# An Investigation of a Dustless System of Dry Drilling

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MONTANA SCHOOL OF MINES

Butte, Montana

MINING 68

Report ~~on~~

# AN INVESTIGATION OF A DUSTLESS SYSTEM OF DRY DRILLING

Submitted to

Professor K. Stout

By

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Report on

AN INVESTIGATION OF A

DUSTLESS SYSTEM OF DRY DRILLING



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May 7, 1954

Residence Hall
Montana School of Mines
Butte, Montana
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Professor Koehler S. Stout
Department of Mining Engineering
Montana School of Mines
Butte, Montana

Dear Professor Stout:

In compliance with your request of February 8, 1954, I am submitting the following report to complete the required work in Mining 68.

This report covers the progress attained by research into the dust control problem of dry drilling. It is a continuation of a previous report, *A Preliminary Investigation of a Dustless System of Dry Drilling*, that I submitted to you on January 18, 1954.

Yours truly,

Norman J. Hardt

Norman J. Hardt

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OF DRY DRILLING

## INTRODUCTION

For many years the problem of removing dust particles while drilling dry has confronted the mining and construction industries. In areas where water is not available, rock drilling is still being done under hazardous dust conditions. It was in an attempt to find a partial solution to this problem that the material contained in this report was compounded.

## CONCLUSION

As can be seen from the accompanying pictures, the method used in attacking the dust problem in drilling dry was unexpectedly successful. Under the assumption that a rock drill could be altered to vacuum clean a drill hole; the following modifications, as shown in Figures 1 through 14, were adapted to a sinker type drill and to a new air-leg combination drill. A screw-on Timkin bit, type "D" thread, with one large center hole was attached to a piece of 1-1/4 inch outside diameter electric seamless tubing. This tubing, approximately 36 inches long and 7/8 inch inside diameter, was machined as shown in Figure 18, with a Timkin 1-1/4 inch "D" thread at one end and a 1-1/4 inch G-D long-hole drill thread at the other end. To the rear end of this hollow drill steel was coupled a swivel, shown in Figures 3, 4, and 19, to remove the dust before it reached the rock drill. A one inch reinforced rubber hose connected the swivel discharge to a Venturi tube vacuum pump (Figures 5 and 7). Sufficient vacuum pressure was obtained by placing a 3/16 inch compressed air nozzle into a critical position in the Venturi tube.

While the actual drilling done was limited, because of failure of unhardened steels and amateur welding and brazing (Figures 10 and 14), this theory of dry drilling was observed to work exceptionally well. No sign of dust or rock particles was apparent near the cutting face. The type rock drilled was a Quartz Monzonite and pieces over 3/8 inch in diameter were observed being discharged from the vacuum pump. There was, furthermore, no sign of clogging or hinderence of dust particles anywhere in the discharge line from the rock bit to the vacuum pump.

Because a standard hex drill shank is welded onto the swivel, it can easily be slipped into the chuck of a sinker or an air-leg with no additional modification. It is apparent, with results obtained from the testing operation, that the drill steel and swivel can be of smaller diameter, possibly one inch outside diameter and 5/8 inch inside diameter, and still work successfully. It is doubtful that much less than a 5/8 inch inside diameter hole in the drill steel would permit passage of sufficient air velocities through the steel and the swivel to effectively carry away all the dust with the type vacuum pump used. For discharge air volumes and static pressure in inches of water of the vacuum pump, reference is made to Figure 20.

There has been some disagreement among local engineers concerning the cooling characteristics of this vacuum drill. The theory has been expressed that the volume and velocity of dry air actually moved by the vacuum pump would be insufficient to adequately cool the rock bit during deep-hole drilling. This concept would be difficult to prove or disprove without extensive additional drilling tests. However, during the limited actual drilling conducted, there was no sign of excessive heating of rock bit or drill steel.

METHOD OF ATTACK

There have been a number of dustless dry drills designed in the past, but few have been even partially successful. Only the Holman DRYDUCTOR drill, of British design, has come close to being satisfactory. The big trouble with the DRYDUCTOR is its reported inability to draw dust from down holes. It is my belief that part of the difficulty of the DRYDUCTOR could be corrected by enlarging the inside diameter of the steel from 3/8 inch to 5/8 inch. Reference as to the size of the DRYDUCTOR steel is from a letter of the Goodman Manufacturing Company.

It was decided to use 1-1/4 inch O.D. and 7/8 inch I.D. seamless tubing for the purpose of this experiment. It was felt that the low resistance factor of this 7/8 inch I.D. steel would permit passage of sufficient volume of air to effectively carry all the dust particles from the cutting edge of the bit. An article, appearing in the Engineering and Mining Journal, concerning the use of seamless tubing as drill steel is quoted as follows:

"A New Angle in Drilling Research"

"By way of exploring the possibility of cutting drilling costs still further, a mid-western operator recently started experiments using 1-1/4 inch seamless electric steel tubing in place of drill steel. This tubing was shanked and threaded. Results with the first trial batch of about 5000 pounds were very satisfactory. The footage drilled before breaking was about 400 feet compared with approximately 112 feet obtained with convential drill steel. Some 1-1/8 inch tubing was then tried but with very unsatisfactory results, the reason for this failure being as yet unknown.

The company is now starting a new series of tests with the 1-1/4 inch tubing, thinking it may shed some light on the failure of the smaller tubing."[1]

As is shown in Figure 2, the steel used in this experiment was of large inside bore. This drill steel, of slightly longer than starter length, was threaded for a 1-1/4 inch Timkin "D" bit (1-7/8 inch across cutting edge). Detailed drawings of this Timkin thread are found in Figures 17 and 18.

The drill steel was designed to couple to a swivel, so the rear end of the drill steel was threaded with a 1-1/4 inch long-hole coupling, No. CL5-400-GD, purchased from the Gardner Denver Company of Quincy, Illinois. One end of the swivel shank was also threaded to receive this Gardner Denver 1-1/4 inch coupling. Into the other end of the swivel a 4-1/4 inch standard hex drill steel shank (Figures 3, 4, and 19) was welded which enabled the hollow steel and swivel to be slipped into the chuck of an I.R. Jackleg. Previous to this, a 3-1/4 inch drill shank was welded into the swivel end to permit installation onto a standard 3-1/4 inch chuck equipped sinker drill.

The swivel shaft was machined to 1.250 inches for a distance of 7 inches measured from the end of the G-D long-hole thread, and then shouldered. Into this machined surface were drilled five 3/8 inch holes 90 degrees apart rotating around the shaft, as shown in Figures 3 and 19. These 3/8 inch holes permitted the uninterrupted flow of dust particles from the drill steel to the outer swivel sleeve. This outer sleeve was fabricated from a piece of steel pipe measuring approximately 2-1/2 inch I.D. and six inches long. Circular pieces of 1/4 inch plate measuring 2-1/2 inches in diameter

1. Engineering and Mining Journal, Volume 151, Dec. 1950, p. 104.

were brazed onto the ends of the pipe sleeve and then bored to 1.6000 inches.

Brass sleeve bearings measuring 1.250 inches I.D. and 1.600 inches O.D. were machined to permit the outer sleeve to ride free on the rotating inner swivel shaft. These bearings, as shown in Figures 3, 4, and 19, have an actual outside bearing length of 1/2 inch and another 1/2 inch of shoulder that tends to hold the outer sleeve from sliding horizontally on the swivel shaft. This shoulder is approximately 1-3/4 inches in diameter and is held firmly against the swivel sleeve by the G-D coupling at one end and the shoulder of the swivel shaft on the other end. In the side of the swivel sleeve, a one inch bored hole permitted the inserting and welding of a piece of 3/4 inch standard pipe six inches long, to which the discharge hose can be attached.

To this 3/4 inch pipe a length of one inch noncollapsing rubber hose was attached (Figure 7and 8). The other end of this hose was attached to the intake side of the vacuum pump (Figure 5). The pump, of course, is a venturi tube with a compressed air nozzle inserted in a critical position. It is the high pressure air ejected through this nozzle into the venturi chamber that causes the vacuum effect. This partial vacuum is actually small in inches of mercury, but produces a high volume of air through the venturi tube. It is the volume and speed of the air rather than the pressure difference that makes the venturi tube an effective pump for this particular experimental design. It can be seen from the graph on Figure 20 that 500 cubic feet of air per minute is obtained through this venturi if the design specifications are followed. Figure 15 of this report shows a detailed plan of the venturi tube used in this design. Figure 6 shows this venturi pump in operation.

Further, it is planned to discharge the dust from the rear of the venturi through a cloth bag to a permanent dust collector underground, and into the atmosphere some distance from the drill for surface operations.

TEST DATA

Throughout the month of November, 1953, the venturi pump was tested for its ability to pick up and dispose of extensive amounts of various size dust particles. Difficulty in obtaining sufficient air pressure from available compressors made these tests rather inconclusive. Results of Test 1 on November 6, 1953 are quoted as follows:

"Test 1 Nov. 6, 1953 1:30 pm"

1. Air pressure limited to 50 lbs. (Upper cutoff at 50 lbs.)
2. Volume of air used with 3/16 inch dia. nozzle is under 160 cubic feet per minute.
3. At this pressure the size of particles is of no immediate consequence. Particles 3/8 inch dia. are picked up with no apparent difficulty.
4. Increase in air pressure would undoubtedly increase weight and volume of dust particles picked up each minute.
5. It is noted that the compressed air nozzle is of too light a material (structurally) to withstand bending strains. The nozzle will probably have to be made of 3/16 inch (inside) heavy duty steel pipe.
6. One inch hose is also too heavy for the light weight of the venturi tube, both at the high pressure side and at the vacuum side.
7. Tests were stopped at 3:45 pm.

s/ N. J. Hardt"

Tests conducted during the month of April, 1954, with an air pressure of 100 psi, have shown that the venturi pump can easily handle all the weight and volume of dust particles that it might be confronted with during ordinary drilling operations. Results of Tests 5 and 6 are quoted as follows:

"Test 5 April 23, 1954 1:30 pm"

1. Air pressure steady at 100 psi.
2. Dry Drill Modification installed on a sinker drill (Figure 7).
3. Compressed air line and vacuum hose hooked up to venturi vacuum pump (Figure 5).
4. Breast holes drilled into Quartz-Monzonite wall (Figure 9).
5. Vertical holes also drilled into cement and brick floor (Figure 8).
6. All dust particles, including pieces 3/8 inch in dia., were removed successfully from the cutting face (Figure 6).
7. At 2:45 pm the swivel piece developed a welding failure at the junction of the swivel shank and the hex drill shank (Figure 10).
8. Test concluded at 3:00 pm.
9. Witnessed by Professor Koehler S. Stout and representatives of a local machine shop, (Names on request).

s/ N. J. Hardt

April 23, 1954"

"Test 6 April 28, 1954 1:00 pm"

1. Air pressure steady at 100 psi.

2. Dry Drill Modification installed on an air-leg (Figures 11 and 12).

3. Compressed air line and vacuum hose hooked up to venturi vacuum pump (Reference to No. 3 in Test 5, See Figure 5).

4. Breast holes drilled into Quartz-Monzonite wall by an air-leg (Figure 13).

5. All dust particles were removed successfully from the cutting face.

6. At 2:30 pm a brazing failure developed in swivel sleeve (Figure 14), necessitating future welding instead of brazing on all parts where any appreciable stress will be felt. It was also assumed that this failure was the result of binding caused by excess bending of the soft tubing used in place of regular hardened drill steels.

7. Tests concluded at 2:45 pm.

8. Witnessed by Professor Koehler S. Stout, Robert Hall, representatives of two rock drill manufacturers, and the superintendent of a local machine shop (Names on Request).

s/ N. J. Hardt

April 28, 1954"

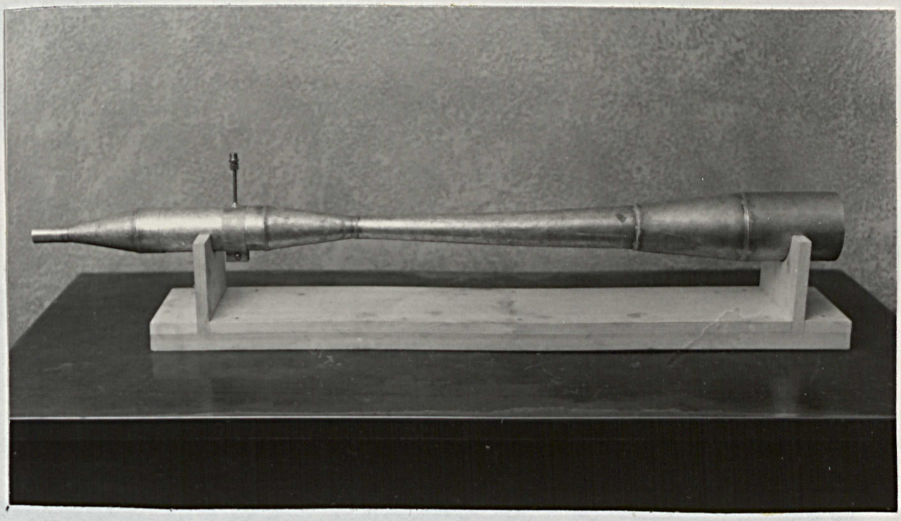


Fig. 1 Venturi Tube Vacuum Pump

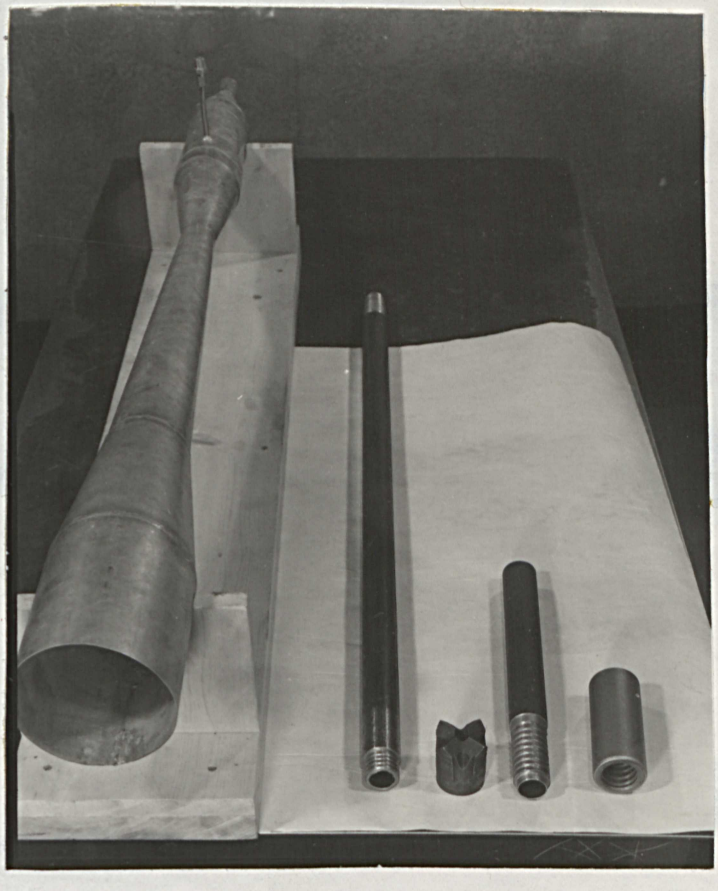


Fig. 2 Venturi Tube and Drill Steel
with unfinished Swivel

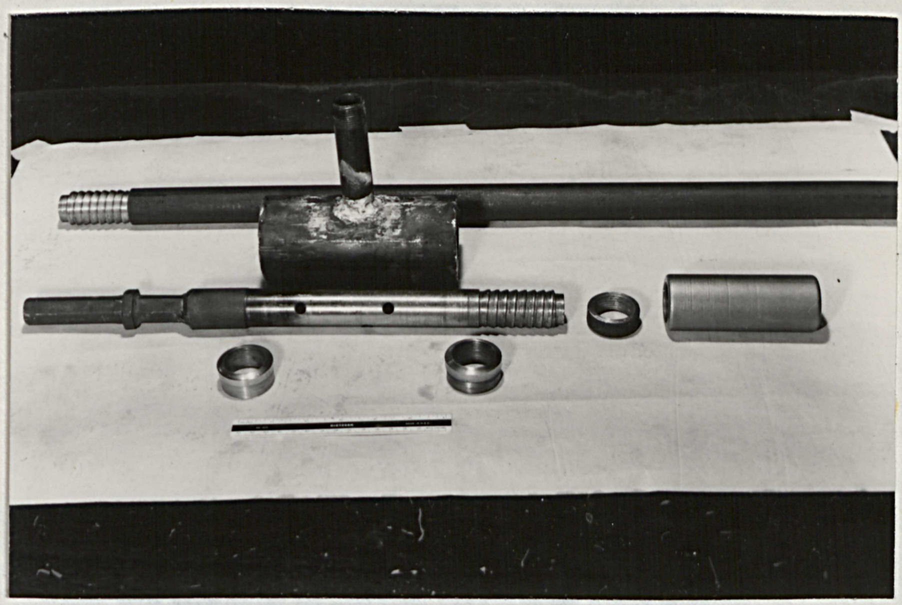


Fig. 3 Disassembled Swivel Showing
Component Parts

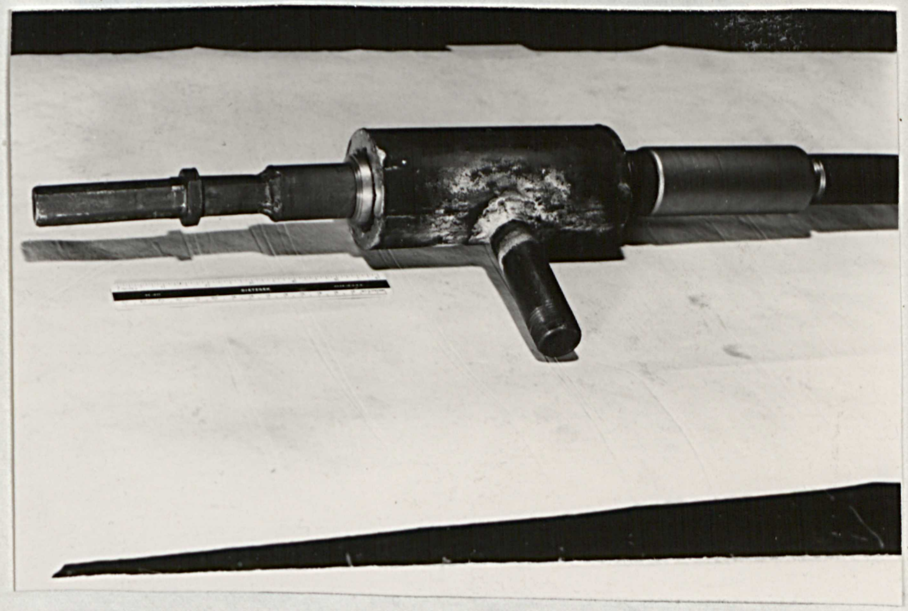


Fig. 4 Assembled Swivel Coupled to Drill Steel by
1-1/4" CL5-400-GD Coupling

Fig. 5 Vacuum Pump Showing Vacuum Hose and Compressed Air Line

Fig. 6 Vacuum Pump in Operation

Fig. 7 Dry Drilling Modification
Installed on Jack Hammer

Fig. 8 Jack Hammer Drilling
Down Holes

Fig. 9 Drilling Breast Holes with a Jack Hammer

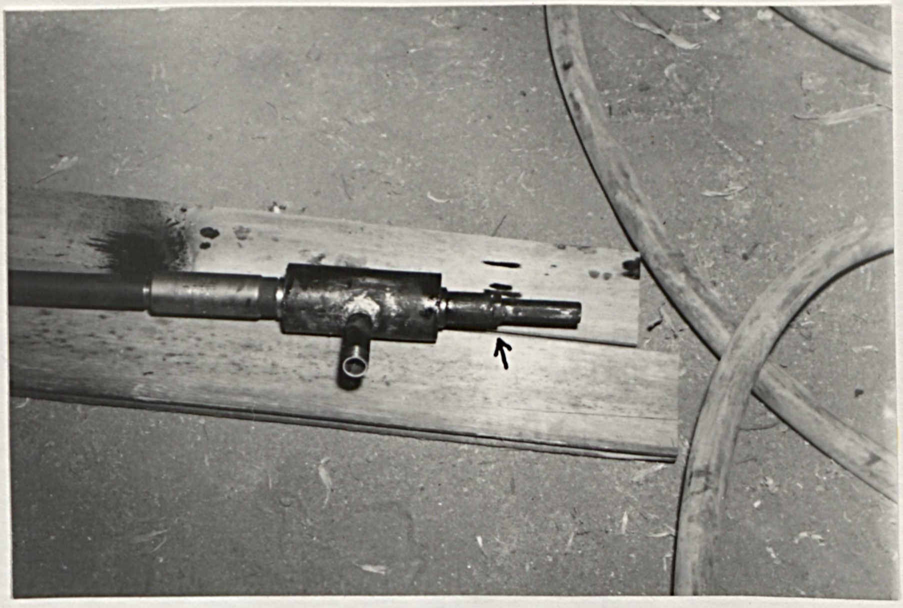


Fig. 10 Arrow Showing Welding Failure in Swivel Shank

Fig. 11 Left-hand view of Dry Drill Modification Installed on Jackleg

Fig 12 Right-hand view of Jackleg Modification

Fig. 13 Test Drilling

Fig. 14 Brazing Failure of Swivel

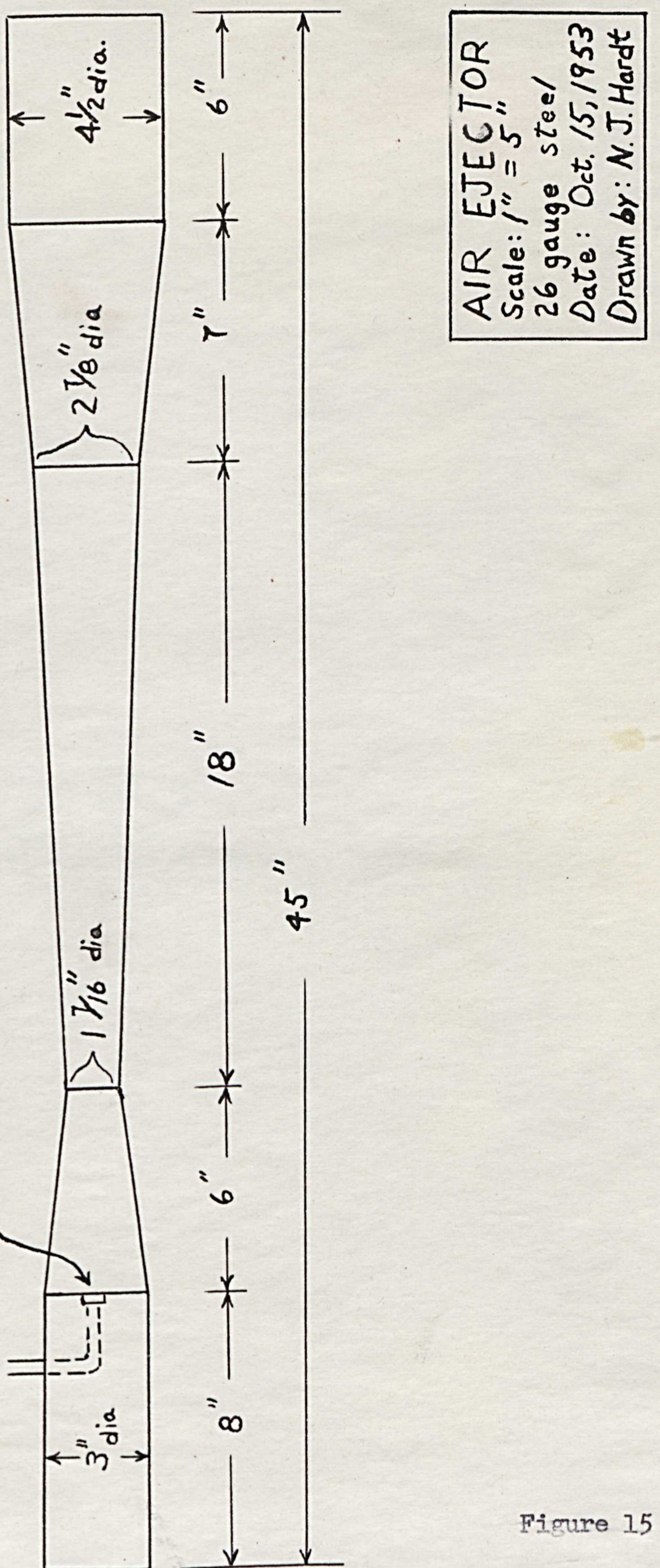



Figure 15

Venturi Tube

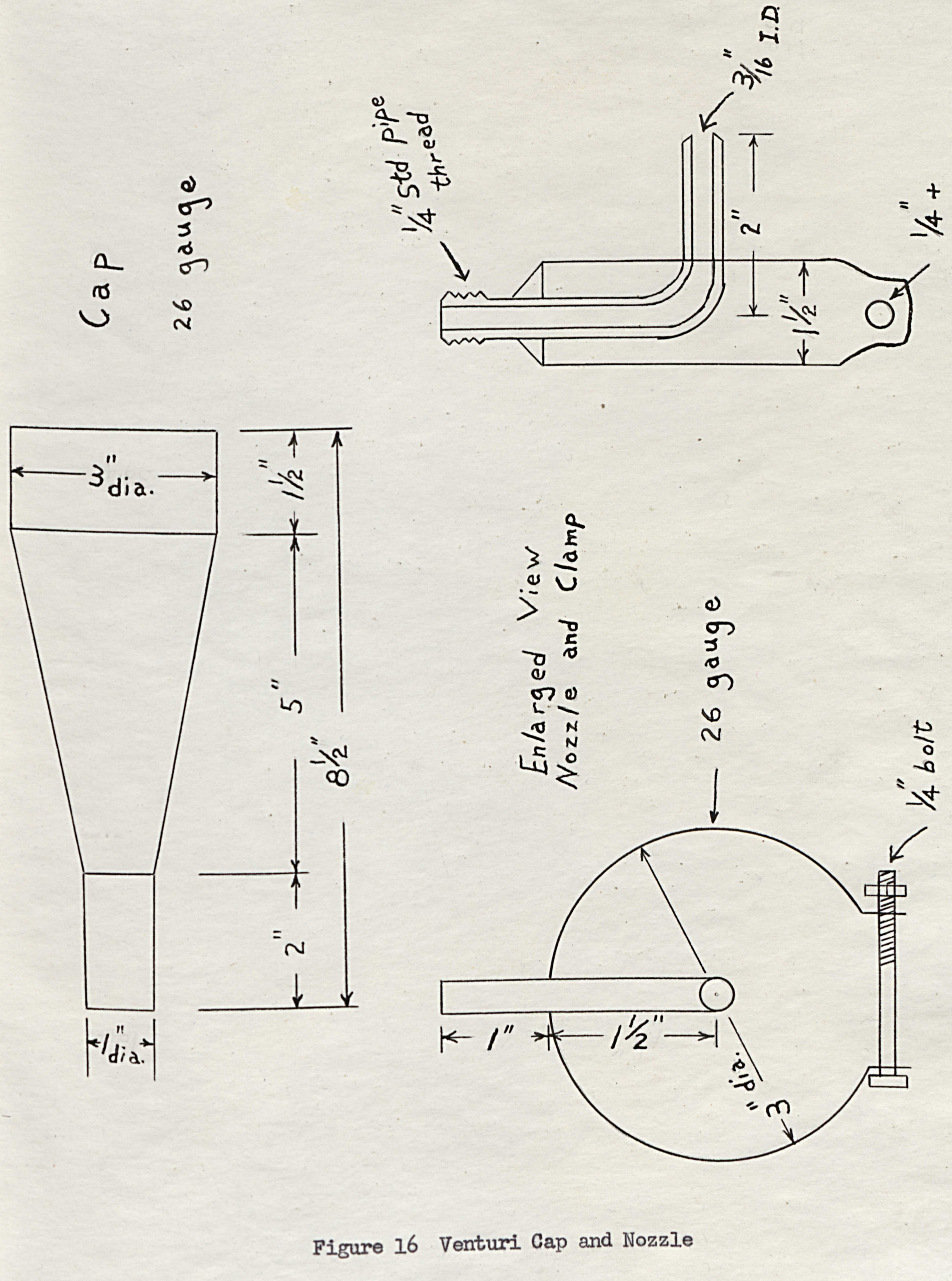
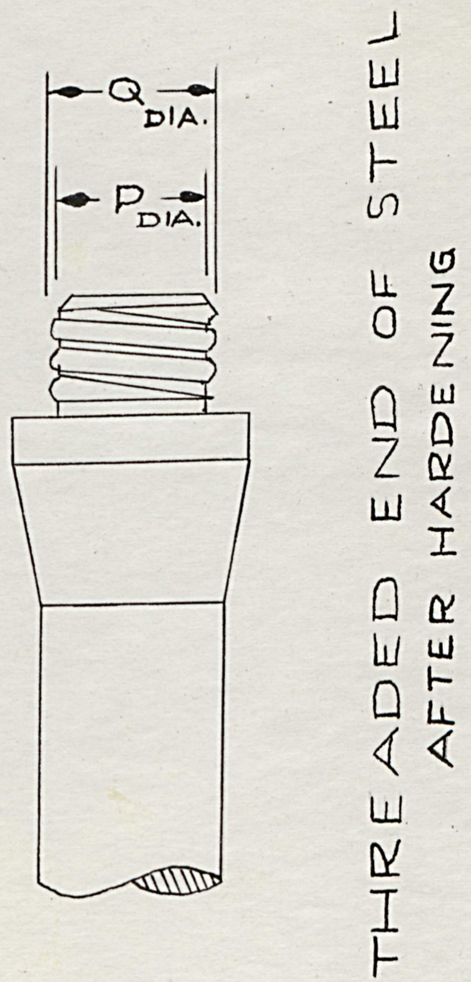



Figure 16  Venturi Cap and Nozzle




| STEEL | | P | Q |
|---|---|---|---|
| D | | 1.010 ± .002 | 1.180 ± .002 |

Figure 17 Timkin Finished Thread

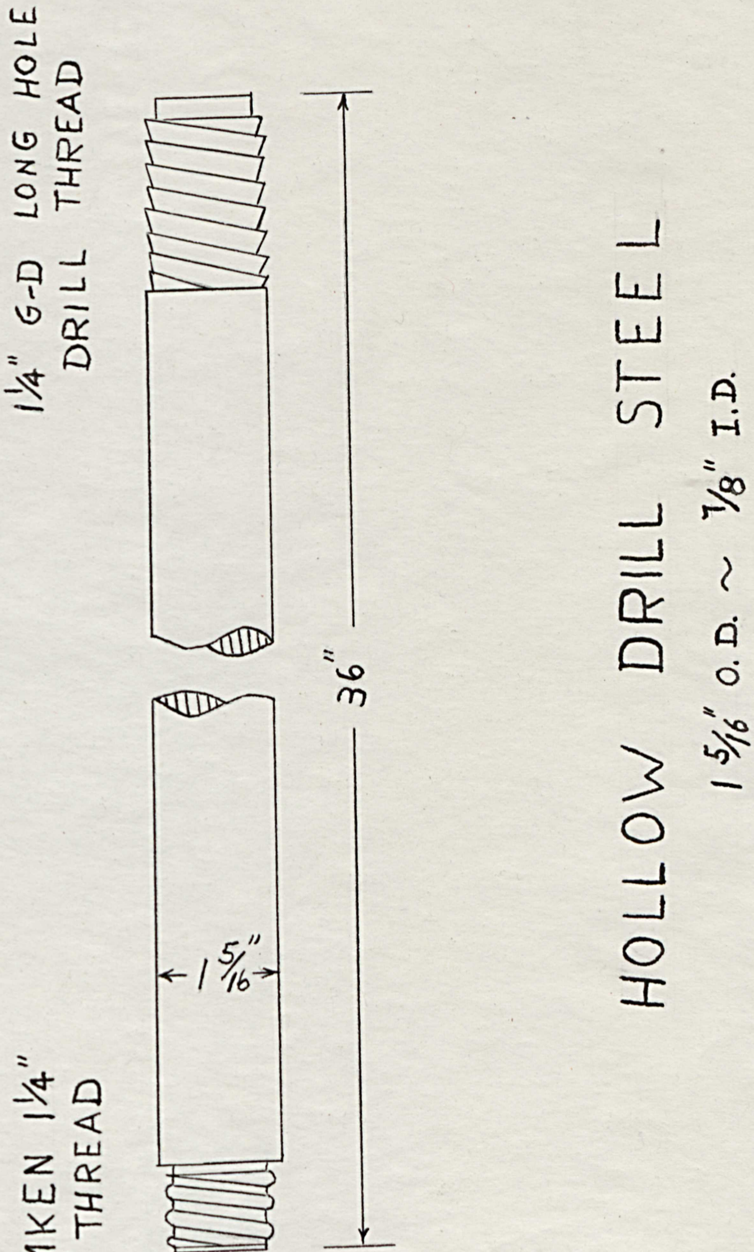



Figure 18 Hollow Drill Steel

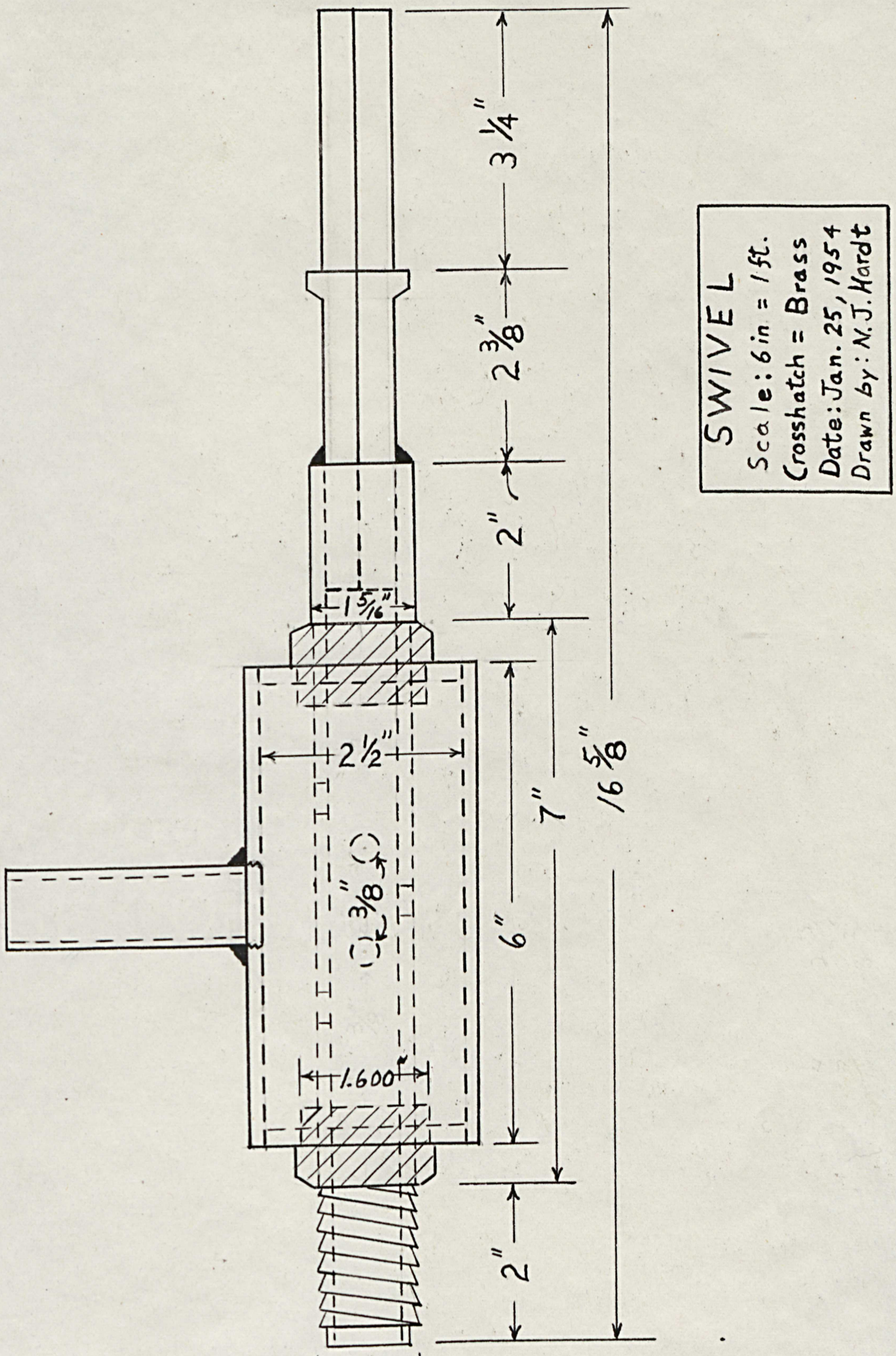



Figure 19 Swivel

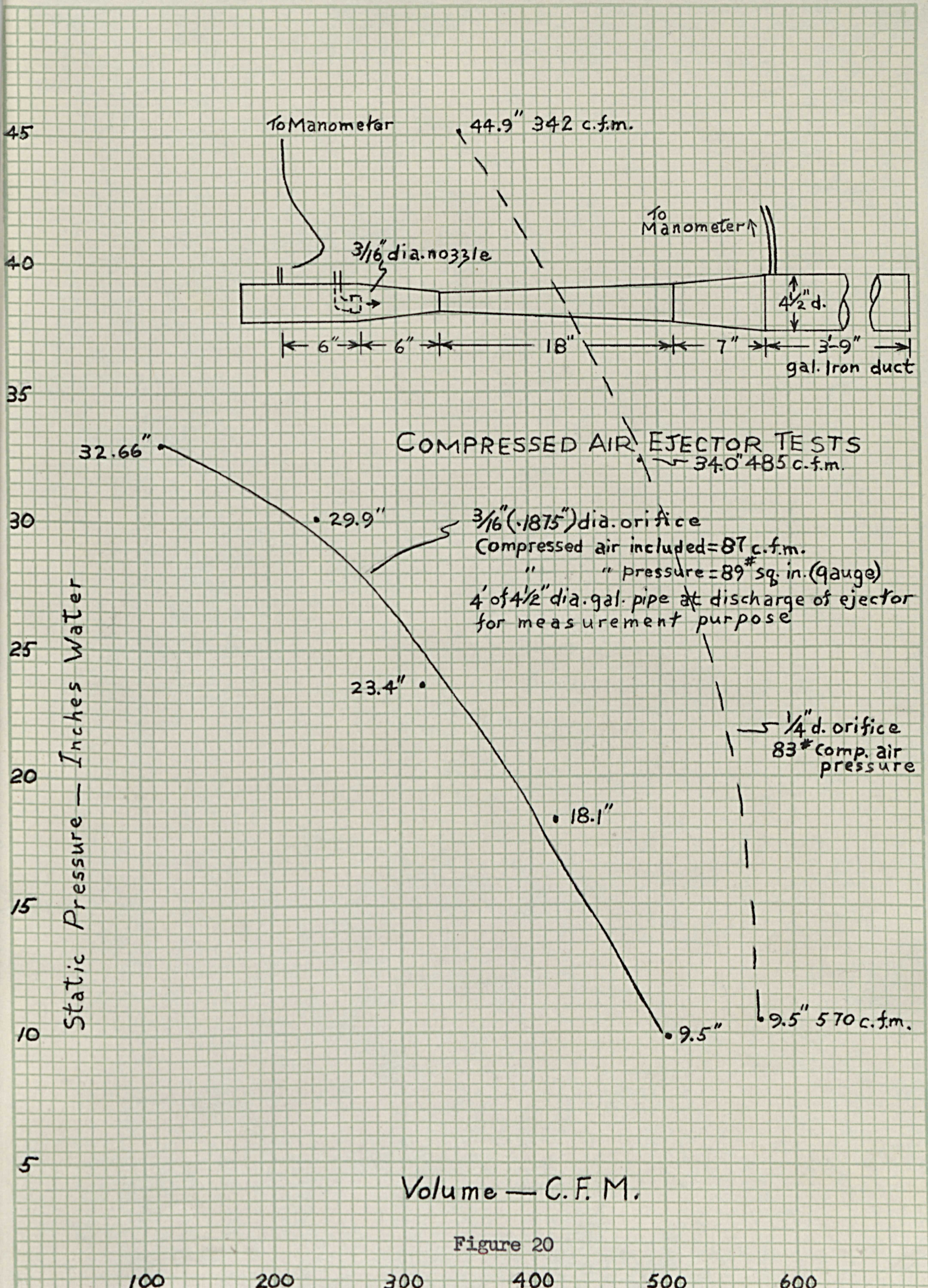

COMPRESSED AIR EJECTOR TESTS
To Manometer
3/16" dia. nozzle
To Manometer
4½" d.
6"
6"
18"
7"
3'-9"
gal. Iron duct
44.9" 342 c.f.m.
34.0" 485 c.f.m.
32.66"
29.9"
23.4"
18.1"
9.5"
9.5" 570 c.f.m.
3/16" (.1875") dia. orifice
Compressed air included = 87 c.f.m.
" " pressure = 89# sq. in. (gauge)
4' of 4½" dia. gal. pipe at discharge of ejector for measurement purpose
¼" d. orifice
83# comp. air pressure
Static Pressure — Inches Water
Volume — C.F.M.
45
40
35
30
25
20
15
10
5
100
200
300
400
500
600

Figure 20